Preface

Polar Microbiology: The Ecology, Biodiversity, and Bioremediation Potential of Microorganisms in Extremely Cold Environments explores the field of polar microbiology and, in particular, the environmental impact of hydrocarbon contamination and the potential for microbial bioremediation. The polar regions of this planet include the Antarctic continent and the area north of the tree line of the Arctic Circle. Ice dominates much of the Antarctic continent and the Arctic Ocean. In fact, the polar environment is the coldest on Earth and poses significant challenges to life in the Arctic and the Antarctic. Yet, in this extremely cold environment, populations of microorganisms thrive and carry out critical ecological functions. These microorganisms are adapted to growing at low temperatures and have diverse and often unique metabolic capabilities.

Although they have had only limited exposure to pollutants, many microorganisms that are indigenous to Arctic and Antarctic ecosystems are able to degrade pollutants. It is this metabolic capacity that forms the basis for bioremediation as a potential treatment for hydrocarbons that may contaminate polar environments. Contamination may happen as a result of oil extraction and transport in the Arctic and human activities in both the northern and southern polar regions.

Currently, much of the polar environment is relatively undisturbed by direct human activities. However, global warming is causing the melting of ice, and the depletion of the atmospheric ozone is exposing polar environments to increased ultraviolet radiation. It is evident that the polar environment is changing, and increasing human activities threaten to bring about significant pollution in the polar terrestrial and aquatic ecosystems. In particular, human activities pose serious risks of environmental contamination with petroleum hydrocarbons, especially in the Arctic due to oil exploration, marine transportation, and human habitation, and in the Antarctic due to tourism and scientific research activities.

It is critical that we exercise all prudent measures to prevent the environmental contamination of polar regions. However, if we fail, we must have contingency plans for abating pollution levels thereby restoring the ecosystem. It is within this context that this book examines the diversity of polar microorganisms and their abilities to degrade petroleum hydrocarbons that may contaminate ice, soil, and both marine and freshwater aquatic environments in the Arctic and the Antarctic. In the Antarctic, increased scientific knowledge about microbes is being generated as scientific research activities have taken on a priority. In the Arctic, much is known about the practical problems of dealing with pollutants.

Pollution with petroleum hydrocarbons has accompanied polar exploration from its inception and now seems to be an unavoidable consequence of oil exploration and extraction in the Arctic and scientific research activities in the Antarctic. Since the first landing on the Antarctic continent by Captain John Davis in 1821 (in the Cecilia islands at Hughes Bay in the Antarctic Peninsula), numerous expeditions have been completed resulting in the establishment of permanent research stations and bases representing over 30 nations.

Even the earliest polar expeditions by Scott, Shackleton, and Amundsen polluted the environment as they carried out their historic explorations. These early explorers brought large quantities of supplies, including petroleum fuels, to support their activities as they sought to reach the North and South Poles. When the expeditions ended, materials that contaminated the environment—including stored fuels—were left behind. Corrosion and weathering of wooden structures led to leakages into the environment. Consequently, high concentrations of polyaromatic hydrocarbons, such as anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, fluorene, and pyrene, as well as benzo[a]anthracene, benzo[a]pyrene, and fluoranthene, which are recognized carcinogens, have contaminated Antarctic soils under and around the historic fuel depots.* In the Arctic, many early exploration wells were not properly capped and many are now surrounded by oozing oil, resulting in the contamination of these historic sites, which need to be remediated.

Since 1960, human presence in the Antarctic continent has increased significantly, thereby requiring a greater need for energy to power the research stations and for aviation and ground transportation refueling. It has therefore become necessary to have year-round storage of hydrocarbon-based fuels, such as diesel and petroleum, at bases and locations where temporary research stations have been established. Such activities have all too frequently resulted in accidental oil spills causing the contamination of ice, soil, lakes, and coastal sediments and waters. In the Arctic, the development of oil wells and pipelines to transport oil southward has resulted in the oil pollution of many previously pristine environments.

Petroleum hydrocarbon spills in the Antarctic and Arctic environments have created pockets of microbial consortia in which biodegradative microorganisms have been selected and have naturally become enriched over time with the hydrocarbon and diesel fuels acting as the carbon source. This book is a compilation of the state of scientific knowledge about the microbial populations that are present in polar ecosystems and the diversity of their genes and physiological capabilities. It provides an overview of the extremophilic microorganisms that inhabit polar ecosystems and their potential for microbial bioremediation in the cold polar environments. All the chapters have been written by leading investigators in the field of polar microbiology. This is the first book to present a broad overview of the study of the ecology, the diversity, and the bioremediation potential of microorganisms in extremely cold polar environments. It should therefore serve as a very valuable resource for scientists and those charged with environmental protection and the management of polar regions.

Asim K. Bej
Birmingham, Alabama

Jackie Aislabie
Hamilton, New Zealand

Ronald M. Atlas
Louisville, Kentucky

* For a discussion of the environmental pollution caused by early Antarctic expeditions see Blanchette, R.A., B.W. Held, J.A. Jurgens, J. Aislabie, S. Duncan, and R.L. Farrell. 2004. Environmental pollutants from the Scott and Shackleton expeditions during the "Heroic Age" of Antarctic exploration. *Polar Record* 40: 143–151.